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Ikenaga et al.

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(54) **RESIN-ATTACHED LEAD FRAME, METHOD FOR MANUFACTURING THE SAME, AND LEAD FRAME**

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(2013.01)

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H01L 33/56; **H01L 2224/48091**; **H01L**
2224/48247; **H01L 23/49861**

USPC **257/676**, **98**, **E23.066**
See application file for complete search history.

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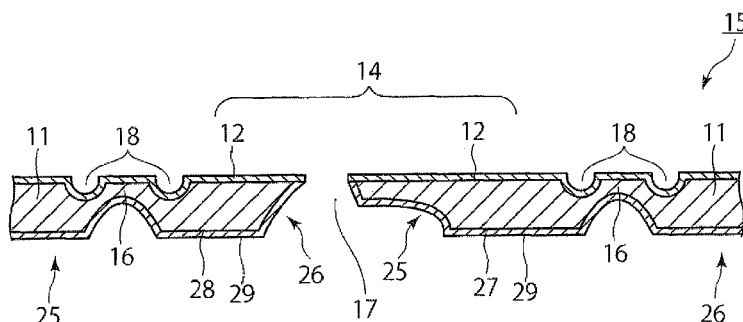
Primary Examiner — Latanya N Crawford

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(57) **ABSTRACT**

A resin-attached lead frame includes a lead frame main body having a plurality of die pads (LED element resting portions) and a plurality of lead portions spaced from the die pads, the lead frame main body further including LED element resting regions each formed over an area including an upper surface of each of the die pads and an upper surface of each of the lead portions. A reflecting resin section surrounds each LED element resting region of the lead frame main body. A vapor-deposited aluminum layer or a sputtered aluminum layer is provided on respective upper surfaces of the LED element resting regions of the lead frame main body.

18 Claims, 14 Drawing Sheets



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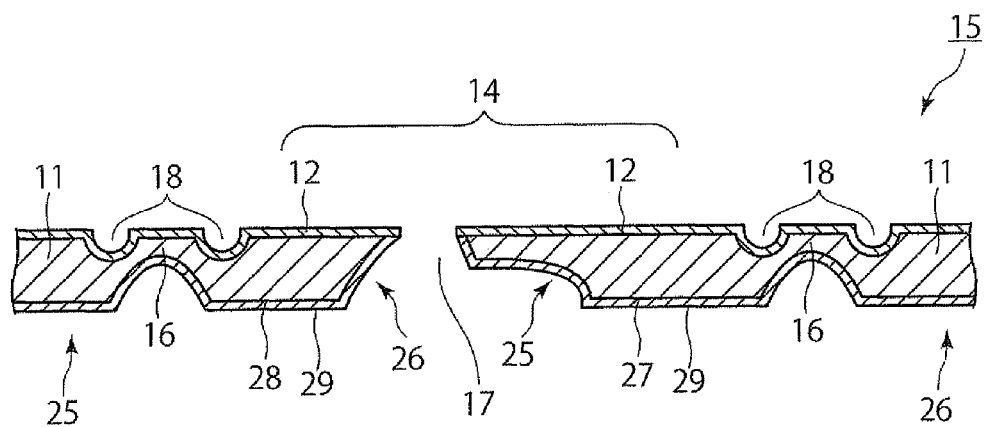


FIG. 1

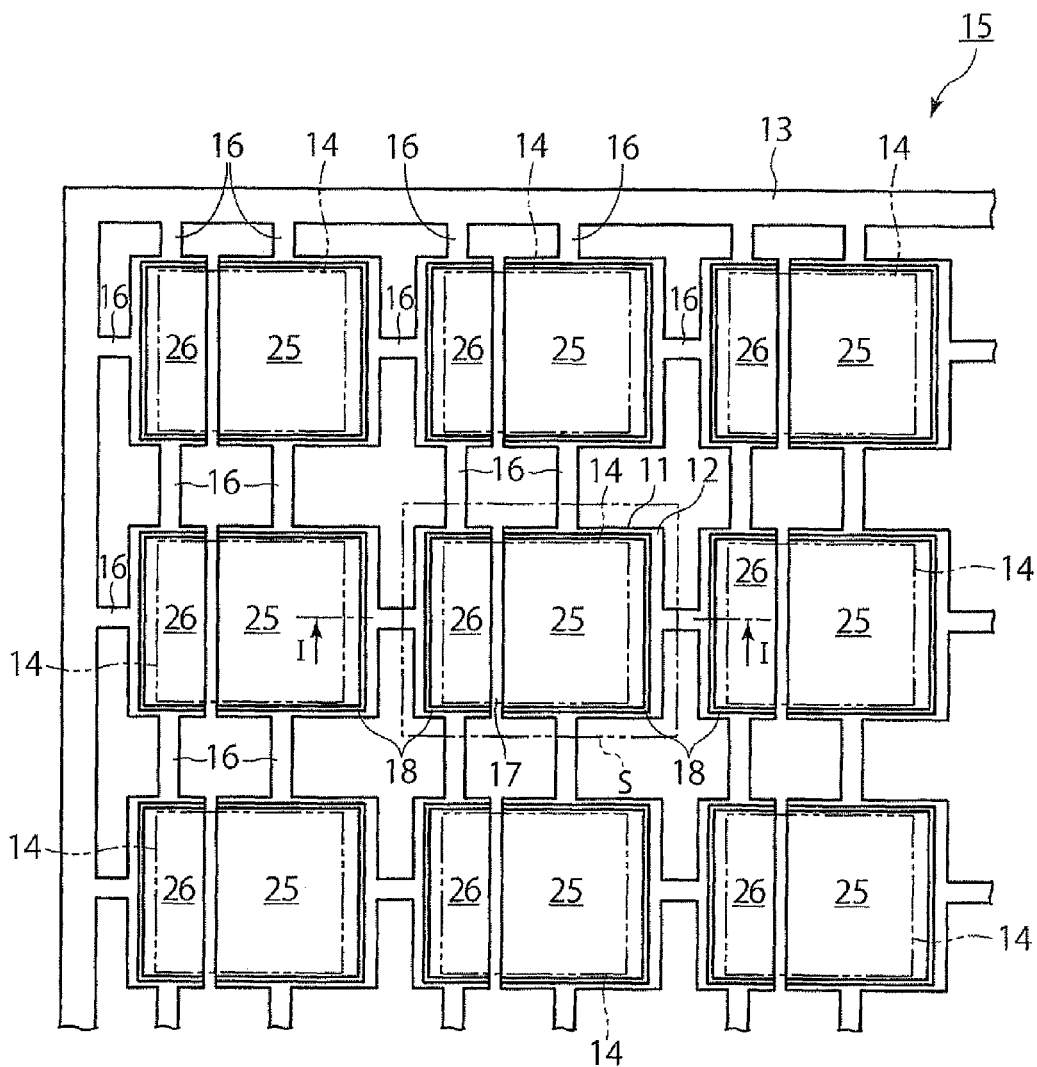


FIG. 2

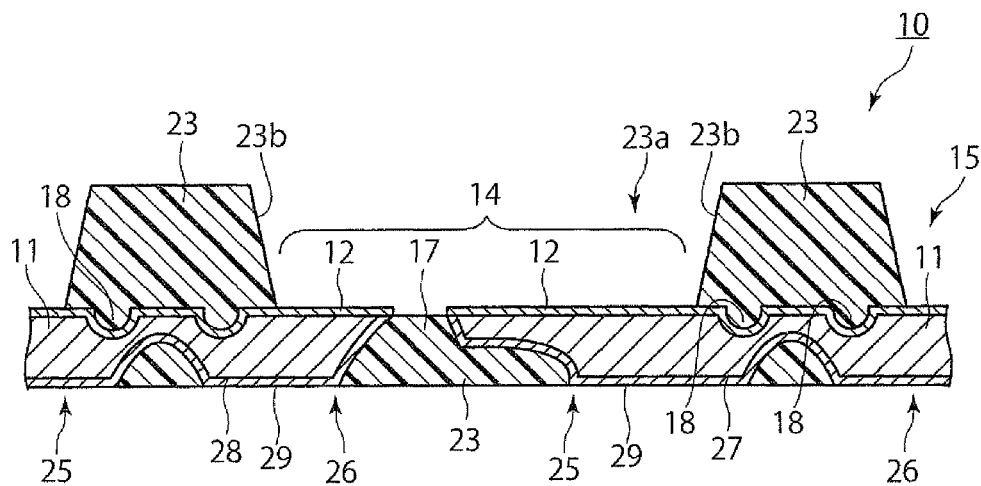


FIG. 3

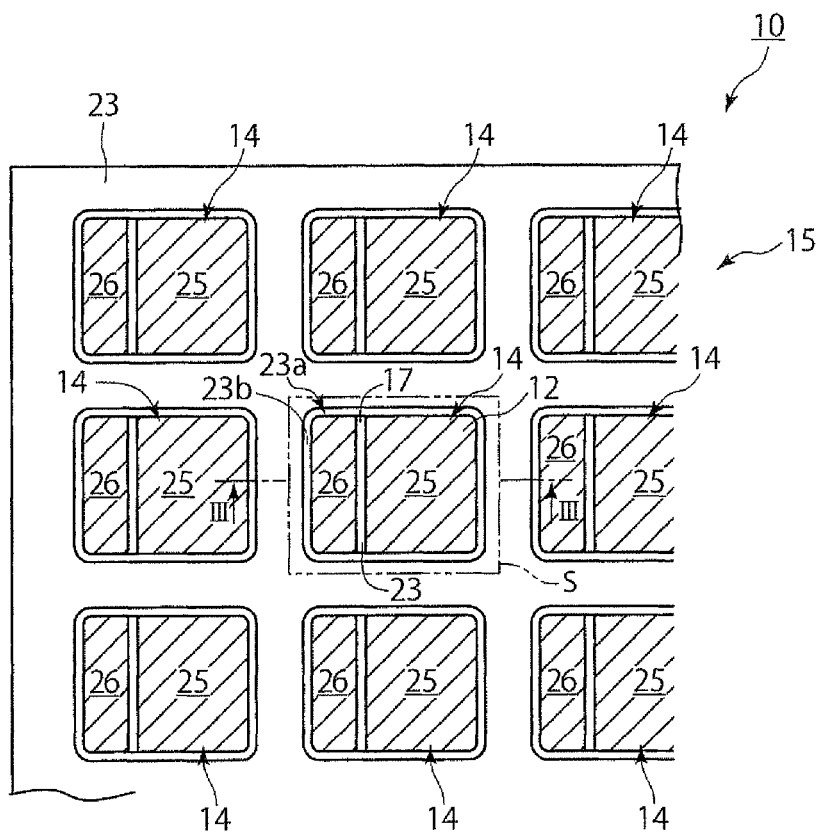


FIG. 4

FIG. 6

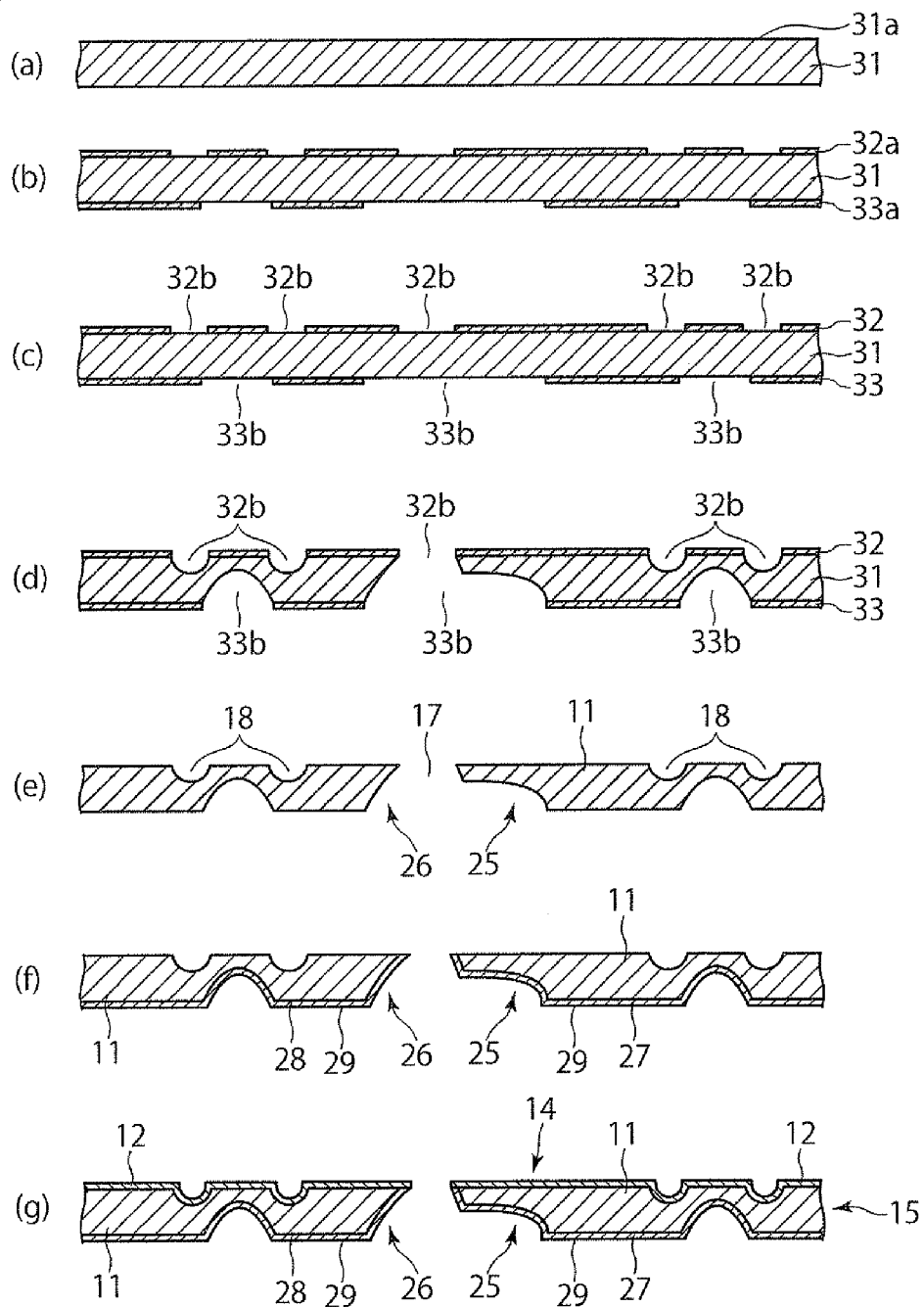


FIG. 7

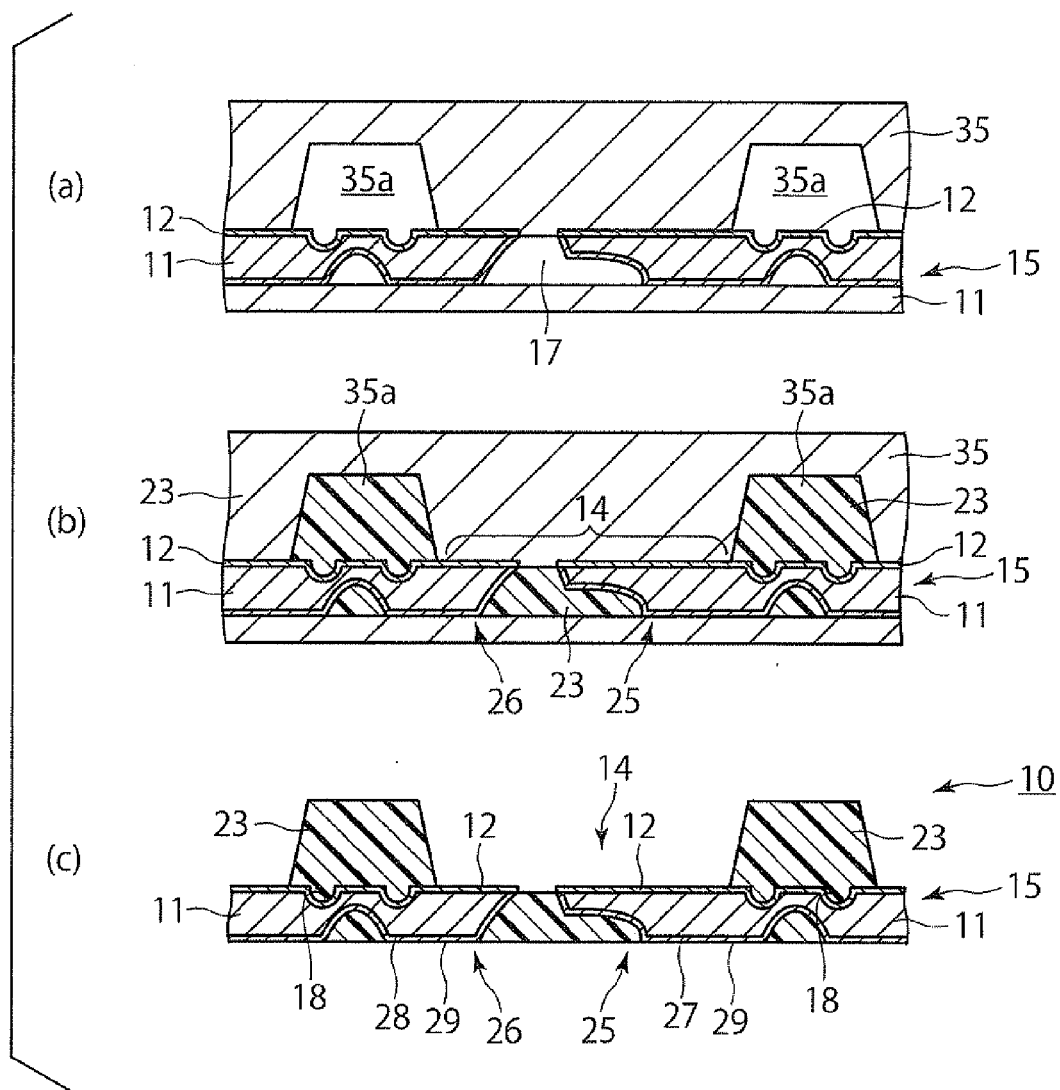


FIG. 8

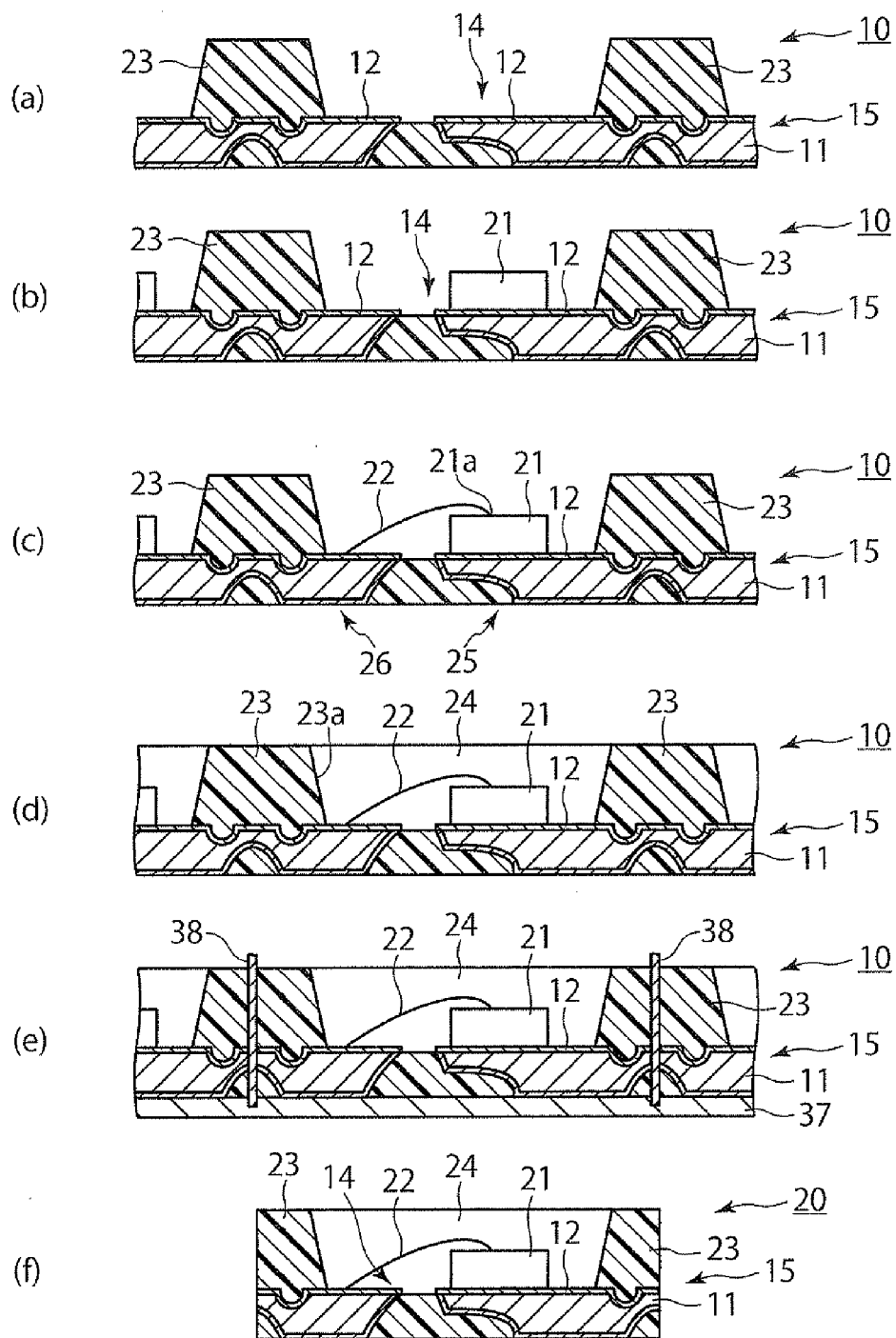


FIG. 9

FIG. 10

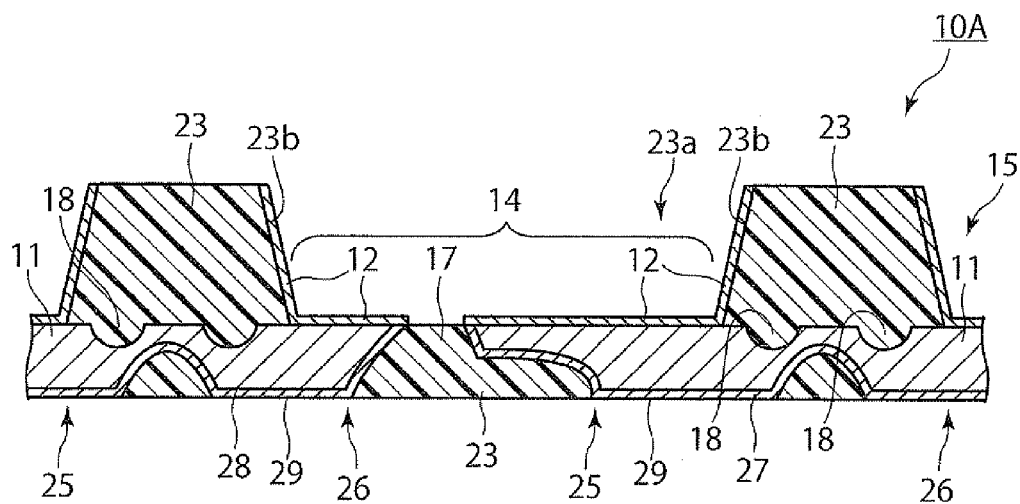


FIG. 11

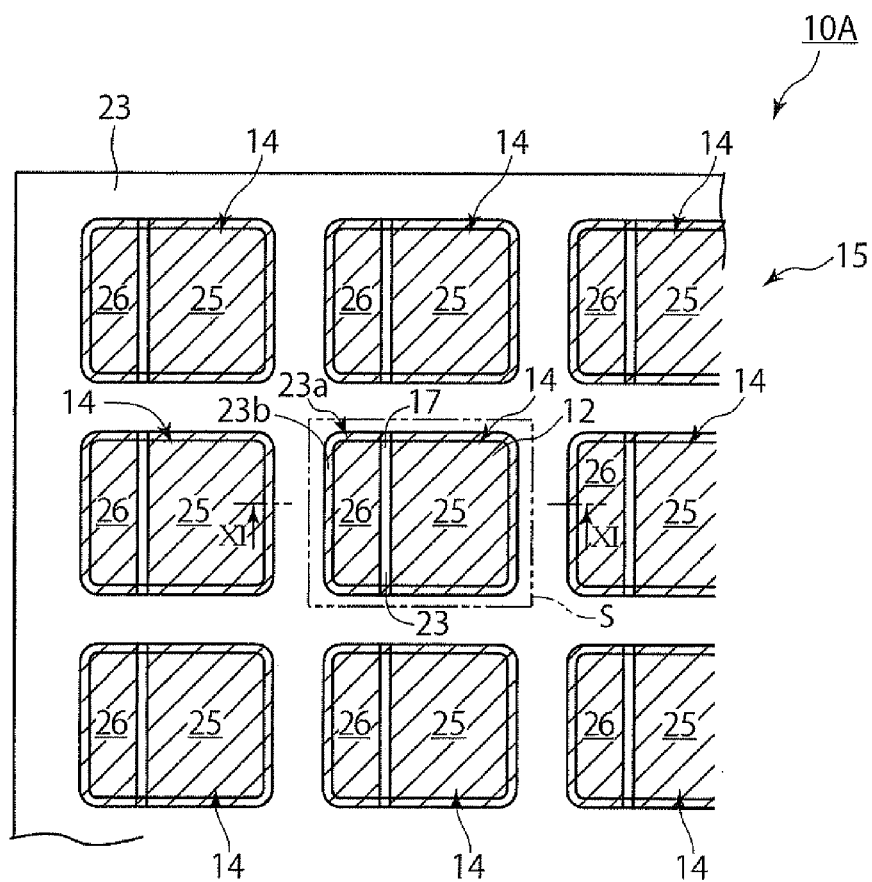


FIG. 12

FIG. 14

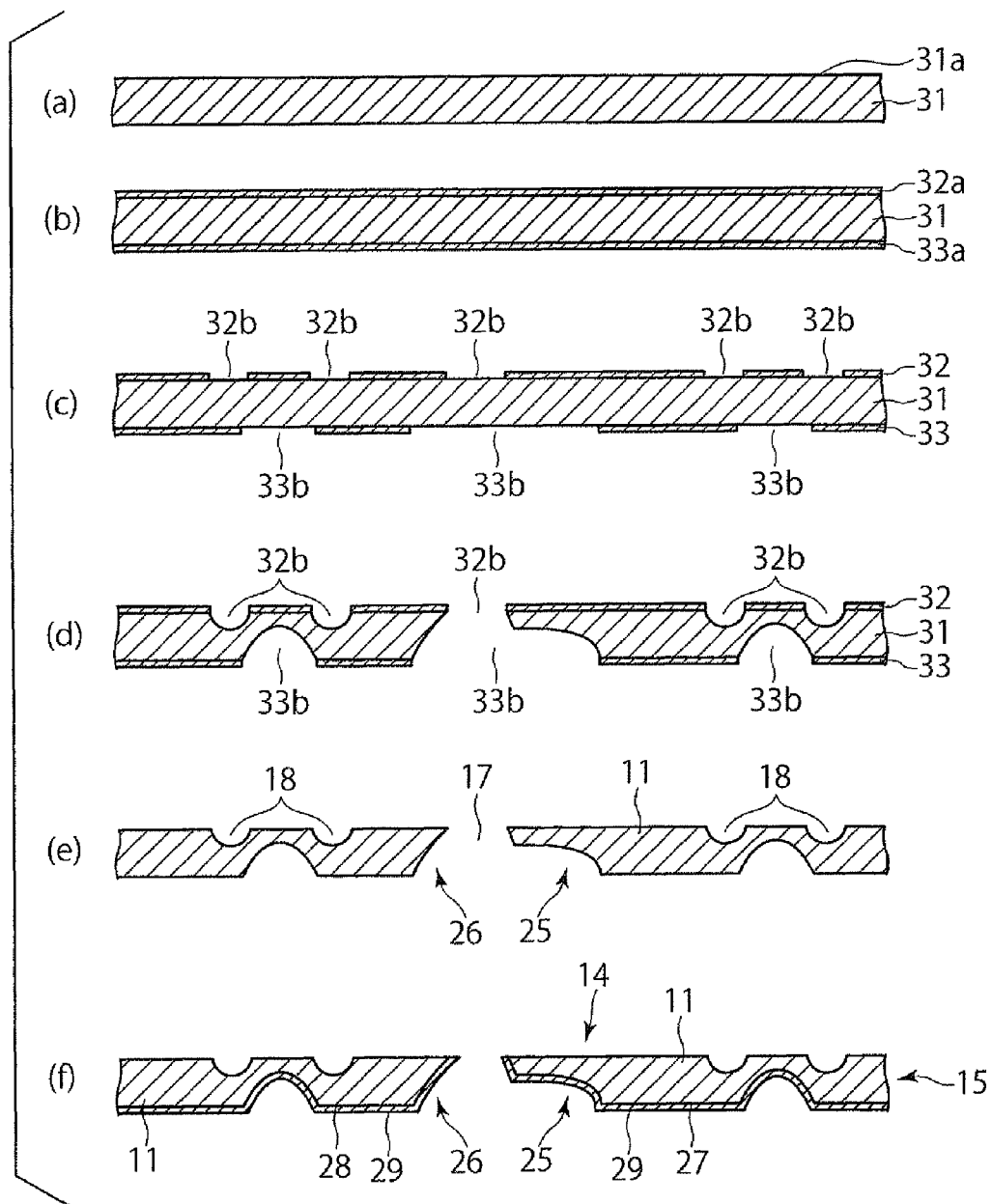


FIG. 15

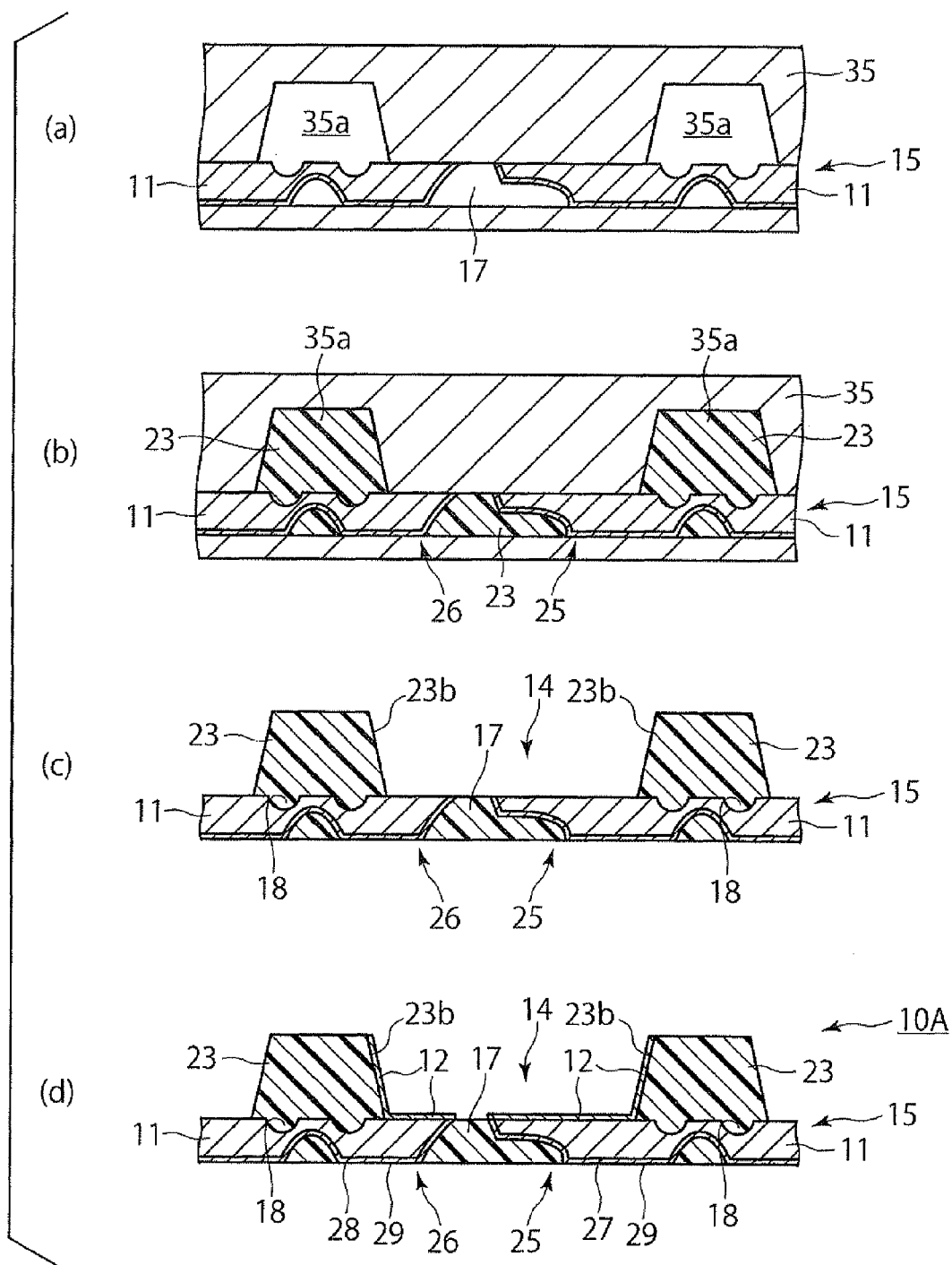


FIG. 16

FIG. 18

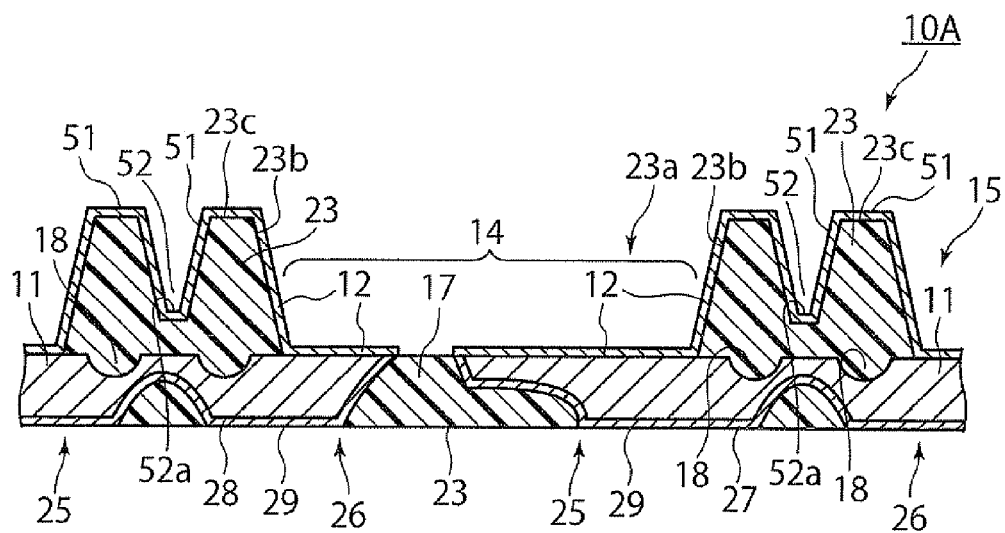


FIG. 19

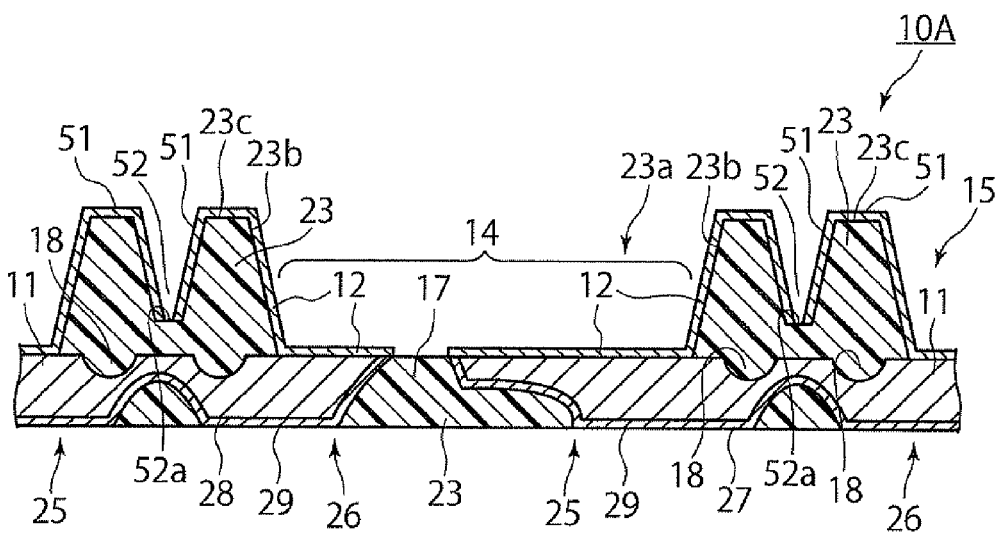


FIG. 20

RESIN-ATTACHED LEAD FRAME, METHOD FOR MANUFACTURING THE SAME, AND LEAD FRAME

TECHNICAL FIELD

The present invention relates to a resin-attached lead frame used for resting LED elements thereupon, to a method for manufacturing the lead frame, and to a lead frame.

BACKGROUND ART

In recent years, optical devices, especially LED devices, are expanding their applications as illumination for cellular phones, or as backlights for liquid crystals. These applications are expanding to the general lighting or illumination recently replacing incandescent light bulbs. In general, however, the light-emission efficiency of LED devices in one wafer has a tendency to vary significantly. In addition, these LED devices are still too low in light-emission efficiency to find their use in general lighting/illumination applications, and thus a plurality of LED elements need to be mounted in one LED device.

Among the packaging techniques for these LED devices are one in which LED elements are mounted on an organic substrate of a glass epoxy or the like and after wire bonding, the LED elements are sealed with an epoxy-based transparent resin and then separated into individual pieces using a method called singulation. In another packaging technique, a reflecting plate formed from a white resin such as polyphthalamide (PPA) is molded as a reflecting resin portion on a ceramic substrate, then after LED elements have been mounted on the reflecting plate and wire-bonded, the LED elements are sealed with an epoxy-based transparent resin and separated into individual pieces by singulation. In yet another technique, a reflecting plate is molded with a white resin, such as PPA, on a lead frame, then after LED elements have been mounted on the reflecting plate and wire-bonded, the LED elements are sealed with a transparent resin and separated into individual pieces by singulation.

PRIOR ART LITERATURE

Patent Documents

Patent Document 1: JP-A-2005-136379

As outlined above, for improved light-extraction efficiency (luminous flux) of an LED package, a premolding of a reflecting plate formed from a synthetic resin is used as a substrate on which LED elements are to be mounted. Traditionally, lead frames having a totally silver-plated surface to enhance their light-reflection efficiency are also used. Depending upon the type of synthetic resin constituting the reflecting plate, however, the ultraviolet rays emitted from the LED elements may cause yellowish discoloration due to deterioration, thus resulting in light extraction efficiency decreasing over time. Additionally, the silver plating of the lead frame causes a reaction with the hydrogen sulfide contained in air, and leads to brownish discoloration.

The present invention has been made with the above taken into consideration, and an object of the invention is to provide a resin-attached lead frame, its manufacturing method, and lead frame adapted to enhance extraction efficiency of light emissions from LED elements included in a semiconductor device, and to prevent the lead frame from degrading with time.

SUMMARY OF THE INVENTION

A first aspect of the present invention is a resin-attached lead frame, comprising: a lead frame main body including a plurality of LED element resting portions and a plurality of lead portions each spaced from the corresponding one of the LED element resting portions, the lead frame main body further including LED element resting regions each formed over an area including an upper surface of each of the LED element resting portions and an upper surface of each of the lead portions; and a reflecting resin section surrounding each of the LED element resting regions of the lead frame main body; wherein a vapor-deposited aluminum layer or a sputtered aluminum layer is provided on respective upper surfaces of the LED element resting regions of the lead frame main body.

A second aspect of the present invention is a resin-attached lead frame, comprising: a lead frame main body including an LED element resting portion and a lead portion disposed apart from the LED element resting portion, the lead frame main body further including an LED element resting region formed over an area including an upper surface of the LED element resting portion and an upper surface of the lead portion; and a reflecting resin section surrounding the LED element resting region of the lead frame main body; wherein a vapor-deposited aluminum layer or a sputtered aluminum layer is provided on an upper surface of the LED element resting region of the lead frame main body.

In the resin-attached lead frame according to either of the first and second aspects of the present invention, the vapor-deposited aluminum layer or the sputtered aluminum layer is further provided on an inner wall of the reflecting resin section as well.

In the resin-attached lead frame according to the first aspect of the present invention, the plurality of LED element resting regions of the lead frame main body are arranged lengthwise and breadthwise.

The lead frame main body of the resin-attached lead frame according to either of the first and second aspects of the present invention is formed from any one of copper, a copper alloy, and a 42-alloy; wherein, of the lead frame main body, at least the upper surface of the LED element resting region is worked into a mirror-like finish having a roughness level of 0.01 μm to 0.10 μm in arithmetic average height "Sa" and 2 μm to 18 μm in roughness curvilinear element average length "Sm".

In the resin-attached lead frame according to either of the first and second aspects of the present invention, a silver-plated layer is provided on a lower surface of the lead portion as well as on a lower surface of the LED element resting portion of the lead frame main body.

In the resin-attached lead frame according to either of the first and second aspects of the present invention, grooves for enhancing adhesion between the lead frame main body and the reflecting resin section are formed on an upper surface of the lead frame main body.

In the resin-attached lead frame according to either of the first and second aspects of the present invention, a reflecting metallic layer is provided on an upper surface of the reflecting resin section.

In the resin-attached lead frame according to either of the first and second aspects of the present invention, the upper surface of the reflecting resin section has a part which is cut by dicing, the reflecting resin section is exposed at the part.

In the resin-attached lead frame according to either of the first and second aspects of the present invention, an inward concaved recess is formed on the upper surface of the reflecting resin section.

A third aspect of the present invention is a lead frame comprising: a lead frame main body including a plurality of LED element resting portions and a plurality of lead portions each spaced from the corresponding one of the LED element resting portions, the lead frame main body further including LED element resting regions each formed over an area including an upper surface of each of the LED element resting portions and an upper surface of each of the lead portions; wherein a vapor-deposited aluminum layer or a sputtered aluminum layer is provided on respective upper surfaces of the LED element resting regions of the lead frame main body.

A fourth aspect of the present invention is a lead frame comprising: a lead frame main body including an LED element resting portion and a lead portion disposed apart from the LED element resting portion, the lead frame main body further including an LED element resting region formed over an area including an upper surface of the LED element resting portion and an upper surface of the lead portion; wherein a vapor-deposited aluminum layer or a sputtered aluminum layer is provided on an upper surface of the LED element resting region of the lead frame main body.

A fifth aspect of the present invention is a method for manufacturing a resin-attached lead frame, the method comprising the steps of: providing a lead frame main body including a plurality of LED element resting portions and a plurality of lead portions each spaced from the corresponding one of the LED element resting portions, the lead frame main body further including LED element resting regions each formed over an area including an upper surface of each of the LED element resting portions and an upper surface of each of the lead portions; providing a vapor-deposited aluminum layer or a sputtered aluminum layer on respective upper surfaces of the LED element resting regions of the lead frame main body; and providing a reflecting resin section surrounding each of the LED element resting regions of the lead frame main body.

A sixth aspect of the present invention is a method for manufacturing a resin-attached lead frame, the method comprising the steps of: providing a lead frame main body including a plurality of LED element resting portions and a plurality of lead portions each spaced from the corresponding one of the LED element resting portions, the lead frame main body further including LED element resting regions each formed over an area including an upper surface of each of the LED element resting portions and an upper surface of each of the lead portions; providing a reflecting resin section surrounding each of the LED element resting regions of the lead frame main body; and providing a vapor-deposited aluminum layer or a sputtered aluminum layer on an inner wall of the reflecting resin section as well as on respective upper surfaces of the LED element resting regions of the lead frame main body.

In accordance with the present invention, the vapor-deposited aluminum layer or the sputtered aluminum layer is provided on the upper surfaces of each LED element resting region of the lead frame main body. This achieves efficient reflection of light from LED elements and enhances extraction efficiency of the light from each LED device, while at the same time preventing the lead frame from degrading with time.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a sectional view of a lead frame according to a first embodiment of the present invention, the sectional view being taken along line I-I in FIG. 2;

FIG. 2 is a plan view showing the lead frame according to the first embodiment of the present invention;

FIG. 3 is a sectional view of the resin-attached lead frame according to the first embodiment of the present invention, the sectional view being taken along line in FIG. 4;

FIG. 4 is a plan view showing the resin-attached lead frame according to the first embodiment of the present invention;

FIG. 5 is a sectional view of a semiconductor device relating to the first embodiment of the present invention, the sectional view being taken along line V-V in FIG. 6;

FIG. 6 is a plan view of the semiconductor device relating to the first embodiment of the present invention;

FIG. 7(a) to (g) shows steps for manufacturing the lead frame according to the first embodiment of the present invention;

FIG. 8(a) to (c) shows further steps for manufacturing the resin-attached lead frame according to the first embodiment of the present invention;

FIG. 9(a) to (f) shows steps for manufacturing the semiconductor device according to the first embodiment of the present invention;

FIG. 10 is a sectional view showing the semiconductor device disposed on an electrical interconnection substrate;

FIG. 11 is a sectional view of a resin-attached lead frame according to a second embodiment of the present invention, the sectional view being taken along line XI-XI in FIG. 12;

FIG. 12 is a plan view showing the resin-attached lead frame according to the second embodiment of the present invention;

FIG. 13 is a sectional view of a semiconductor device relating to the second embodiment of the present invention, the sectional view being taken along line XIII-XIII in FIG. 14;

FIG. 14 is a plan view of the semiconductor device relating to the second embodiment of the present invention;

FIG. 15(a) to (f) shows steps for manufacturing the lead frame according to the second embodiment of the present invention;

FIG. 16(a) to (d) shows further steps for manufacturing the resin-attached lead frame according to the second embodiment of the present invention;

FIG. 17 is a sectional view showing a modification of the resin-attached lead frame according to the second embodiment of the present invention;

FIG. 18 is a sectional view showing another modification of the resin-attached lead frame according to the second embodiment of the present invention;

FIG. 19 is a sectional view showing yet another modification of the resin-attached lead frame according to the second embodiment of the present invention; and

FIG. 20 is a sectional view showing a further modification of the resin-attached lead frame according to the second embodiment of the present invention.

MODE FOR CARRYING OUT THE INVENTION

First Embodiment

Hereunder, a first embodiment of the present invention will be described referring to FIGS. 1 to 10.

Lead Frame Configuration

First, a lead frame for resting LED elements, according to the present embodiment is outlined below per FIGS. 1 and

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2. FIGS. 1 and 2 are a cross-sectional view, and a plan view, respectively, of the lead frame according to the present embodiment.

The lead frame 15 shown in FIGS. 1 and 2 includes a lead frame main body 11 having a plurality of LED element resting regions 14, and metallic layers 12 provided on upper surfaces of the LED element resting regions 14 of the lead frame main body 11, the metallic layers 12 each functioning as a reflecting layer for reflecting light emitted from an LED element 21.

The lead frame main body (hereinafter referred to simply as the lead frame body) 11 is formed from a sheet of metal. The metal sheet constituting the lead frame body 11 can be of a material such as copper, copper alloy, or 42-alloy (a Fe alloy with a 42% Ni content). Thickness of the lead frame body 11 depends on a configuration of a semiconductor device. Preferable thickness, however, ranges between 0.1 mm and 0.5 mm, inclusive.

In addition, as shown in FIG. 2, the lead frame body 11 has an outer frame 13, and the plurality of LED element resting regions 14 are arranged lengthwise and breadthwise inside the outer frame 13. The lead frame body 11 further includes a plurality of die pads (LED element resting portions) 25 and a plurality of lead portions 26 each spaced from one of the die pads 25, and each LED element resting region 14 is formed over upper surfaces of one die pad 25 and one lead portion 26. A space 17 to be filled in with the reflecting resin section 23 is formed between the die pad 25 and the lead portion 26. The die pad 25 and the lead portion 26 are coupled to another adjacent die pad 25 and another adjacent lead portion 26, respectively, or to the outer frame 13, via an independent, rod-shaped tie bar 16.

As shown in FIG. 1, a first outer lead portion 27 is formed on a lower surface of the die pad 25, and a second outer lead portion 28 is formed on a lower surface of the lead section 26. On each of the first outer lead portion 27 and the second outer lead portion 28, a silver-plated layer 29 is provided to enhance a degree of contact with solder. The plated layer 29 is preferably 2 μ m to 10 μ m thick.

Each metallic layer 12 may be formed by, for example, vapor deposition or sputtering, and examples of a material constituting the metallic layer can be aluminum, silver, rhodium, palladium, platinum, copper, and the like. An example in which the metallic layer 12 is formed from a vapor-deposited aluminum layer or a sputtered aluminum layer is described below (hereinafter, this metallic layer is also referred to simply as the vapor-deposited aluminum layer or sputtered aluminum layer 12). The vapor-deposited aluminum layer or sputtered aluminum layer 12, functioning as a layer for reflecting the light from the LED element 21, is positioned on the uppermost surface side of the lead frame 15. The vapor-deposited aluminum layer or sputtered aluminum layer 12 is formed by vacuum-vapor-depositing aluminum or sputtering aluminum. The vapor-deposited aluminum layer or sputtered aluminum layer 12 is formed to have an extremely small thickness. More specifically, the thickness preferably ranges between 0.1 μ m and 1.0 μ m, inclusive. The vapor-deposited aluminum layer or sputtered aluminum layer 12 may be formed directly on the lead frame body 11, but may be formed thereupon via a bonding layer formed from, for example, a layer plated with silver (Ag).

In addition, although the vapor-deposited aluminum layer or sputtered aluminum layer 12 in the present embodiment is provided on an entire upper surface of the lead frame body 11 that includes the outer frame 13 and the tie bars 16, the vapor-deposited aluminum layer or sputtered aluminum layer 12 needs only to be formed at least in the LED element

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resting regions 14 on the upper surface of the lead frame body 11. This is because the LED element resting regions 14, not shrouded by the reflecting resin section 23 (described later herein) of the lead frame body 11, are sections that contribute to reflecting the light from each LED element 21.

In another example, the vapor-deposited aluminum layer or sputtered aluminum layer 12 may be absent on a section of the lead frame body surface that is subjected to wire bonding.

In yet another example, the vapor-deposited aluminum layer or sputtered aluminum layer 12 may be absent on a section of the lead frame body surface that is subjected to the mounting of an LED element 21.

In a further example, while the vapor-deposited aluminum layer or sputtered aluminum layer 12 may be provided on the upper surface of the lead frame body 11 via a bonding layer (not shown) formed from a silver-plated layer, the vapor-deposited aluminum layer or sputtered aluminum layer 12 may not be provided on a section of the lead frame body surface that is subjected to wire bonding.

In a further example, while the vapor-deposited aluminum layer or sputtered aluminum layer 12 may be provided on the upper surface of the lead frame body 11 via a bonding layer (not shown) formed from a silver-plated layer, the vapor-deposited aluminum layer or sputtered aluminum layer 12 may not be provided on a section of the lead frame body surface that is subjected to the mounting of an LED element 21.

In a further example, of the lead frame body 11, at least upper surfaces of each LED element resting region 14 are preferably preworked into a mirror-like finish before the vapor-deposited aluminum layer or sputtered aluminum layer 12 is provided on the upper surfaces. Preferable surface roughness of the LED element resting region 14 in this case is such that surface roughness of the LED element resting region 14 as measured using the Optical Surface & Layer Profiling System VertScan 2.0 (manufacturer: Ryoka Systems Inc.) will range between 0.01 μ m and 0.10 μ m, inclusive, in arithmetic average height "Sa" and between 2 μ m and 18 μ m, inclusive, in roughness curvilinear element average length "Sm". This will increase a reflectance of the vapor-deposited aluminum layer or sputtered aluminum layer 12 formed on the upper surface of the LED element resting region 14, and thereby achieve more efficient reflection of the light from the LED element 21.

Furthermore, grooves 18 for enhancing adhesion between the lead frame body 11 and the reflecting resin section 23 are formed on the upper surface of the lead frame body 11. The grooves 18, each having a rectangular shape in a plane view (except at the space 17), are provided along an outer edge of the LED element resting region 14 on the upper surface of the lead frame body 11.

Reference symbol S (double-dotted chain line) in FIG. 2 denotes a region of the lead frame 15 that corresponds to the semiconductor device 20 (see FIGS. 5 and 6) detailed later herein.

While in the present embodiment the lead frame body 11 includes a plurality of die pads 25 and a plurality of lead portions 26 spaced from one of the die pads 25, the lead frame body 11 is not limited to this configuration and needs only to include at least one die pad 25 and one lead portion 26.

Resin-Attached Lead Frame Configuration

Next, a resin-attached lead frame for resting LED elements according to the present embodiment is outlined below per FIGS. 3 and 4. FIGS. 3 and 4 are a cross-sectional view, and a plan view, respectively, of the resin-attached

lead frame according to the present embodiment. In FIGS. 3 and 4, the same elements as those shown in FIGS. 1 and 2 are each assigned the same reference number or symbol.

The resin-attached lead frame 10 shown in FIGS. 3 and 4 is used to rest LED elements 21 (see FIGS. 5 and 6). The resin-attached lead frame 10 includes a lead frame 15 and a reflecting resin section 23 provided on the lead frame 15 and surrounding LED element resting regions 14.

The lead frame 15 includes a lead frame body 11, and the lead frame body 11 includes a plurality of die pads 25 and a plurality of lead portions 26 each spaced from one of the die pads 25. An LED element resting region 14 is formed over upper surfaces of each die pad 25 and each lead portion 26. The lead frame body 11 also has a vapor-deposited aluminum layer or sputtered aluminum layer 12 on upper surfaces of each LED element resting region 14. In FIG. 4, the vapor-deposited aluminum layer or sputtered aluminum layer 12 is shown in hatched form. The lead frame 15 is substantially of the same configuration as that shown in FIGS. 1 and 2, and detailed description of the lead frame configuration is therefore omitted herein.

The reflecting resin section 23 is integrated with the lead frame 15 and has a recess 23a having a substantially rectangular shape in a plane view and surrounding the LED element 21. Inner walls 23b are formed on the inside of the recess 23a. A space 17 filled in with the reflecting resin section 23 also exists between each die pad 25 and each lead portion 26. Details of the reflecting resin section 23 are described later herein.

While in the present embodiment the lead frame body 11 includes a plurality of die pads 25 and a plurality of lead portions 26 spaced from the corresponding die pad 25, the lead frame body 11 is not limited to this configuration and needs only to include at least one die pad 25 and one lead portion 26.

Semiconductor Device Configuration

Next, a semiconductor device fabricated using the resin-attached lead frame shown in FIGS. 2 and 3 is described below per FIGS. 5 and 6. FIGS. 5 and 6 are a cross-sectional view, and a plan view, respectively, of the semiconductor device (SON type) according to the present embodiment. In FIGS. 5 and 6, the same elements as those shown in FIGS. 1 to 4 are each assigned the same reference number or symbol.

As shown in FIGS. 5 and 6, the semiconductor device 20 includes a (singulated) lead frame 15 having a lead frame body 11 and a vapor-deposited aluminum layer or sputtered aluminum layer 12, an LED element 21 rested on a die pad 25 of the lead frame 15, and a bonding wire (electric conductor) 22 that electrically interconnects the LED element 21 and a lead portion 26 of the lead frame 15. The vapor-deposited aluminum layer or sputtered aluminum layer 12 is shown in hatched form in FIG. 6.

In addition, a reflecting resin section 23 with a recess 23a is provided around the LED element 21. The LED element 21 and the bonding wire 22 are integrally sealed with a light-transmissive sealing resin 24. The recess 23a in the reflecting resin section 23 is filled with the sealing resin 24. Of the lead frame body surface, a region in which the sealing resin 24 is provided corresponds to the LED element resting region 14.

Members that constitute the semiconductor device 20 are described in order below.

The lead frame 15 includes the lead frame body 11 having, as described above, the die pad 25 and the lead portion 26, and the vapor-deposited aluminum layer or sputtered aluminum layer 12 provided on the lead frame

body 11 and functioning as a layer for reflecting light emitted from the LED element 21.

If a material formed from compound semiconductor single crystals such as GaP, GaAs, GaAlAs, GaAsP, AlInGaP, and/or InGaN, is appropriately selected for a light-emitting layer, a light-emission wavelength ranging between those of ultraviolet light and those of infrared light, inclusive, can be selected for the LED element 21. A commonly used conventional element can be used as such an LED element 21.

The LED element 21 is fixedly mounted on the die pad 25 (vapor-deposited aluminum layer or sputtered aluminum layer 12), inside the recess 23a of the reflecting resin section 23, via solder or a die-bonding paste. If a die-bonding paste is to be used, the die-bonding paste can be that formed from a light-resistant epoxy resin or silicone resin.

The bonding wire 22 is formed from a highly electroconductive material such as gold, with one end thereof being connected to a terminal section 21a of the LED element 21, and with the other end thereof being connected to an upper surface (on the vapor-deposited aluminum layer or sputtered aluminum layer 12) of the lead portion 26.

The reflecting resin section 23 is formed by, for example, injection-molding a thermoplastic resin over the resin-attached lead frame 10 or by, for example, injection-molding or transfer-molding a thermosetting resin over the resin-attached lead frame 10. The reflecting resin section 23 can vary in shape according to a design of a mold used during the injection molding or transfer molding of the resin. For example, the entire reflecting resin section 23 can be formed into a regularly parallelepipedic shape as shown in FIGS. 5 and 6, or formed into a shape of a cylinder, pyramid/cone, or the like. The recess 23a can have, for example, either a rectangular, circular, elliptical, or polygonal base. The inner walls 23b of the recess 23a may have either a rectilinear cross-sectional shape as shown in FIG. 5, or have a curvilinear one.

A material excelling particularly in heat resistance, weatherability, and mechanical strength is desirably selected for the thermoplastic resin or thermosetting resin used in the reflecting resin section 23. The useable kinds of thermoplastic resin materials are polyamide, polyphthalamide (PPA), polyphenylene sulfide, liquid-crystal polymers, polyether sulphone, polyetherimide, polybutylene terephthalate, polyolefin, cyclopolyolefin, and the like. The useable kinds of thermosetting resin materials are silicone, epoxies, polyimides, and the like. If either of titanium dioxide, zirconium dioxide, potassium titanate, aluminum nitride, and boron nitride is added as a light-reflecting agent to the resin, this increases a reflectance of the light from the light-emitting element, at the base and inner walls 23b of the recess 23a, thus increasing light-extraction efficiency of the entire semiconductor device 20.

For enhancing light-extraction efficiency, a material high in an index of refraction as well as in light transmittance at a light-emission wavelength of the semiconductor device 20 is desirably selected as the sealing resin 24. An epoxy resin or a silicone resin can therefore be selected as a resin that satisfies high heat resistance, weatherability, and mechanical strength requirements. To use a high-luminance LED, in particular, as the LED element 21, the sealing resin 24 is preferably formed from a highly weatherable silicone resin material since the sealing resin 24 is exposed to strong light.

Method of Manufacturing the Lead Frame and the Resin-Attached Lead Frame

Next, a method of manufacturing the lead frame **15** shown in FIGS. **1** and **2**, and the resin-attached lead frame **10** shown in FIGS. **3** and **4** are described below using FIGS. **7(a)** to **(g)** and **8(a)** to **(c)**.

First as shown in FIG. **7(a)**, a metallic substrate **31** of a flat-plate shape is provided. As outlined above, the metallic substrate **31** can be that formed from copper, a copper alloy, a 42-alloy (a Fe alloy with a 42% Ni content), and/or the like. Both sides of the metallic substrate **31** are preferably degreased and cleaned beforehand.

In addition, the metallic substrate **31** preferably has its upper surface **31a** preworked into a mirror-like finish to have a roughness level of 0.01 μm to 0.1 μm in arithmetic average height "Sa" and 2 μm to 18 μm in roughness curvilinear element average length "Sm". Examples of such mirror-like finishing methods can be by using a mirror-like finishing roller during final rolling of the material, or by conducting double-side mirror-like copper plating.

Next as shown in FIG. **7(b)**, entire upper and lower surfaces of the metallic substrate **31** are coated with photosensitive resists **32a** and **33a**, respectively, and then the resists are dried. The photosensitive resists **32a**, **33a** can be conventionally known ones.

Following the above, light exposure of the metallic substrate **31** via a photomask takes place, and developing further follows. Etching resist layers **32** and **33** with desired openings **32b** and **33b**, respectively, are then formed as shown in FIG. **7(c)**.

Next as shown in FIG. **7(d)**, etching of the metallic substrate **31** with an etchant occurs using the etching resist layers **32**, **33** as anti-etching films. An appropriate chemical as the etchant can be selected according to the kind of metallic substrate material to be used. For example, to use copper as the material of the metallic substrate **31**, the substrate can usually be spray-etched from both sides using an aqueous ferric chloride solution.

After that, the etching resist layers **32**, **33** are peeled off, whereby the lead frame body **11** with die pads **25** and lead portions **26** spaced from the die pads **25** will then be obtained as shown in FIG. **7(e)**. Providing half etching at this time will also form grooves **18** on the upper surface of the lead frame body **11**.

Next, the lower surface of the lead frame body **11** is provided with electrolytic plating to deposit a metal (silver) onto a first outer lead portion **27** and a second outer lead portion **28**, thus forming a plated layer **29** for enhanced contact with the solder. This state is shown in FIG. **7(f)**. In this case, the lead frame body **11** goes through steps such as electrolytic degreasing, pickling, chemical polishing, copper striking, water washing, neutral degreasing, cyanide cleaning, and silver plating, in that order. This forms the plated layer **29** on the first outer lead portion **27** and the second outer lead portion **28**. An electroplating solution used in the silver-plating step can be, for example, a silver-plating solution composed mainly of silver cyanide. In an actual process, water washing is added between steps, as required.

Next, aluminum is vapor-deposited or sputtered onto the surface of the lead frame body **11**, whereby as shown in FIG. **7(g)**, the vapor-deposited aluminum layer or sputtered aluminum layer **12** functioning as a reflecting layer is formed on the entire surface of the lead frame body **11** including the LED element resting region **14**.

The formation of the vapor-deposited aluminum layer or sputtered aluminum layer is, more specifically, not limited to the above method, but in a case of vapor deposition, the

vapor-deposited aluminum layer **12** can be formed on the surface of the lead frame body **11** by using parameters of 9×10^{-6} torr in maximum attainable degree of vacuum and 1.5 nm/sec in deposition rate. In a case of sputtering, the sputtered aluminum layer **12** can be formed on the surface of the lead frame body **11** by using parameters of 4×10^{-6} torr in maximum attainable degree of vacuum, 5×10^{-3} torr in film-forming degree of vacuum, and 900 W in sputtering power (for a target size of 5 inches by 18 inches).

In this way, the lead frame **15** with the lead frame body **11** and the vapor-deposited aluminum layer or sputtered aluminum layer **12** formed on the lead frame body **11** is obtained. This state is shown in FIG. **7(g)**.

Next, the reflecting resin section **23** is formed on the vapor-deposited aluminum layer or sputtered aluminum layer **12** of the lead frame **15**. The formation of the reflecting resin section **23** is described in further detail below.

First as shown in FIG. **8(a)**, the lead frame **15** that has been obtained through the steps shown in FIG. **7(a)** to **(g)** is mounted in a mold **35** of an injection molding machine or transfer molding machine (not shown). Cavities **35a** appropriate for a shape of the reflecting resin section **23** are preformed in the mold **35**.

Next, a thermosetting resin is poured from a resin supply section (not shown) of the injection molding machine or transfer molding machine into the mold **35** and then allowed to set. The reflecting resin section **23** is then formed in a section of the lead frame surface, exclusive of the LED element resting region **14**, as shown in FIG. **8(b)**. At this time, the reflecting resin section **23** is also generated in the space **17** between the die pad **25** and the lead portion **26**.

The lead frame **15** with the formed reflecting resin section **23** is removed from the mold **35** after that. In this way, the resin-attached lead frame **10** (see FIGS. **3** and **4**) with the reflecting resin section **23** and the lead frame **15** is obtained. This state is shown in FIG. **8(c)**.

Method of Manufacturing the Semiconductor Device

Next, a method of manufacturing the semiconductor device **20** shown in FIGS. **5** and **6** is described below using FIG. **9(a)** to **(f)**.

First, the resin-attached lead frame **10** with the lead frame **15** and reflecting resin section **23** described in the steps of FIGS. **7(a)** to **(g)** and **8(a)** to **(c)** is fabricated. FIG. **9(a)** shows the fabricated lead frame **10**.

Next, an LED element **21** is mounted on the die pad **25** of the lead frame **15**. In this case, as shown in FIG. **9(b)**, the LED element **21** is rested on and fixed to the die pad **25** (the vapor-deposited aluminum layer or sputtered aluminum layer **12**) of the lead frame **15** by use of solder or a die-bonding paste (this step is called die attaching).

Next as shown in FIG. **9(c)**, the terminal section **21a** of the LED element **21** and an upper surface of the lead portion **26** are electrically connected to each other via a bonding wire **22** (this step is called wire bonding).

After this, the recess **23a** in the reflecting resin **23** is filled in with a sealing resin **24**, whereby the LED element **21** and the bonding wire **22** are sealed with the sealing resin **24**. This state is shown in FIG. **9(d)**.

Next as shown in FIG. **9(e)**, the lead frame **15** is separated for each LED element **21** by dicing the sections of the lead frame **15** that correspond to the reflecting resin section **23** between the LED elements **21**. At this time, the lead frame **15** is first rested on and fixed to a dicing tape **37**, and then the reflecting resin section **23** between the LED elements **21** is cut in a vertical direction using, for example, a blade **38** made of a diamond grinding wheel or the like.

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The semiconductor device **20** shown in FIGS. **5** and **6** is thus obtained. FIG. **9(f)** shows the semiconductor device **20** existing after the reflecting resin section **23** has been cut. Operational Effects of the Present Embodiment

Next, operational effects of the present embodiment having the above configuration are described below using FIG. **10**. FIG. **10** is a sectional view showing the semiconductor device disposed on an electrical interconnection substrate.

As shown in FIG. **10**, the semiconductor device **20** according to the present embodiment is disposed on the interconnection substrate **41**. The interconnection substrate **41** includes a substrate body **42** and interconnection terminal sections **43** and **44** formed on the substrate body **42**. The terminal section **43** of the two interconnection terminal sections is connected to a first outer lead portion **27** via a connecting solder portion **45**. The other terminal section **44** is connected to a second outer lead portion **28** via a connecting solder portion **46**.

In this way, the semiconductor device **20** is disposed on the interconnection substrate **41**. In addition, when current is applied between the paired interconnection terminal sections **43** and **44**, the current is further applied to the LED element **21** on the die pad **25**, thus activating the LED element **21**.

At this time, light from the LED element **21** passes through the sealing resin **24** and is released from an upper surface of the sealing resin **24**, or reflects from the inner walls **23b** of the recess **23a** in the reflecting resin section **23** and is released from the surface of the sealing resin **24**. Alternatively, the light from the LED element **21** reflects from the surface of the vapor-deposited aluminum layer or sputtered aluminum layer **12** and is released from the surface of the sealing resin **24**.

In the present embodiment, the vapor-deposited aluminum layer or sputtered aluminum layer **12** is provided on the surface of the LED element resting region **14** of the lead frame body **11**. This makes the light from the LED element **21** reflect efficiently, hence enhancing extraction efficiency of the light from the LED element **21**. In addition, the above prevents the lead frame **15** from degrading with time, since the aluminum constituting the vapor-deposited aluminum layer or sputtered aluminum layer **12** is free from degradation due to presence of hydrogen sulfide in air.

As described above, in accordance with the present embodiment, the vapor-deposited aluminum layer or sputtered aluminum layer **12** is provided on the surface of each LED element resting region **14** of the lead frame body **11**. This makes the light from the LED element **21** reflect efficiently and hence enhances the extraction efficiency of the light from the LED element **21**. In addition, the above prevents the lead frame **15** from degrading with time.

Furthermore, the provision of the vapor-deposited aluminum layer or sputtered aluminum layer **12** in the present embodiment raises adhesion between the lead frame **15** and the sealing resin **24**. The state of wire bonding with the bonding wire **22** and the die attaching of the LED elements **21** are also maintained at an appropriate level.

If the vapor-deposited aluminum layer or sputtered aluminum layer **12** is provided via a bonding layer formed from a silver-plated layer, since on the section subjected to wire bonding, the underlying silver (the silver-plated layer) will break the thin aluminum and form an alloy of the silver and the wire, a further desirable bond will be obtained and stronger wire bonding attained.

If the vapor-deposited aluminum layer or sputtered aluminum layer **12** is not provided on the section subjected to wire bonding, since energy for the silver to break an oxide film of the aluminum during wire bonding is not needed, a

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bonding temperature, parameters relating to use of ultrasonic waves, and other parameters can be alleviated.

If the vapor-deposited aluminum layer or sputtered aluminum layer **12** is not provided on the section where the LED element **21** is to be mounted, a heat-releasing route via the die pad **25** becomes short, which results in improved heat release characteristics.

For example, if the vapor-deposited aluminum layer or sputtered aluminum layer **12** is provided via a bonding layer formed from a silver-plated layer and not provided on the section subjected to wire bonding, since, the surface of the silver-plated layer can be directly wire-bonded as in conventional technology, a bond with a bonding wire **22** of gold, for example, can be maintained at a high strength level.

For example, if the vapor-deposited aluminum layer or sputtered aluminum layer **12** is provided via a bonding layer formed from a silver-plated layer and not provided on the section where the LED element **21** is to be mounted, when the LED element **21** is to be connected by soldering, for example, high wettability of the solder on that section generates no void in the solder and allows reliable mounting of the entire LED element surface.

Second Embodiment

Next, a second embodiment of the present invention is described below referring to FIGS. **11** to **16**. FIGS. **11** to **16** show the second embodiment of the present invention. The second embodiment shown in FIGS. **11** to **16** differs from the first embodiment in that a vapor-deposited aluminum layer or sputtered aluminum layer **12** is also provided on inner walls **23b** of a reflecting resin section **23**, and all other elements are substantially the same as those in the first embodiment. In FIGS. **11** to **16**, the same elements as those of the embodiment shown in FIGS. **1** to **10** are each assigned the same reference number or symbol, and detailed description of these elements is omitted herein.

Resin-Attached Lead Frame Configuration

First, a resin-attached lead frame according to the present embodiment is outlined below per FIGS. **11** and **12**. FIGS. **11** and **12** are a cross-sectional view, and a plan view, respectively, of the resin-attached lead frame according to the present embodiment.

As shown in FIGS. **11** and **12**, the resin-attached lead frame **10A** according to the present embodiment includes a lead frame **15** and a reflecting resin section **23**.

The lead frame **15** includes a lead frame body **11**, and the lead frame body **11** includes a plurality of die pads **25** and a plurality of lead portions **26** each spaced from one of the die pads **25**. An LED element resting region **14** is formed over upper surfaces of each die pad **25** and each lead portion **26**. The reflecting resin section **23** is provided in such a form as to surround each of the LED element resting regions **14** of the lead frame body **11**.

In the present embodiment, a metallic layer (in this case, a vapor-deposited aluminum layer or sputtered aluminum layer) **12** is provided on upper surfaces of each LED element resting region **14** of the lead frame body **11**. The metallic layer **12** is also provided on the inner walls **23b** of the reflecting resin section **23**. That is to say, the vapor-deposited aluminum layer or sputtered aluminum layer **12** continuously extends along the inner walls **23b** of the reflecting resin section **23** from the surface of the LED element resting region **14**. The vapor-deposited aluminum layer or sputtered aluminum layer **12** is shown in hatched form in FIG. **12**. The metallic layer **12** formed on the inner walls **23b** of the reflecting resin section **23** as well as on the surface of the

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LED element resting region **14** is not limited to a vapor-deposited aluminum layer or sputtered aluminum layer and may include layers of silver, rhodium, palladium, platinum, copper, and/or the like.

In this case, the vapor-deposited aluminum layer or sputtered aluminum layer **12**, unlike that of the resin-attached lead frame **10** shown in FIGS. **3** and **4**, is not provided between the lead frame body **11** and the reflecting resin section **23**. Instead, the vapor-deposited aluminum layer or sputtered aluminum layer **12** is provided only in each LED element resting region **14** on the surface of the lead frame body **11**.

In addition, as shown in FIG. **12**, in order to prevent short-circuiting between the die pad **25** and the lead portion **26**, the vapor-deposited aluminum layer or sputtered aluminum layer **12** is not provided on a section adjacent to a space **17**, on the inner walls **23b** of the reflecting resin section **23**.

The resin-attached lead frame **10A** is substantially of the same configuration as that of the resin-attached lead frame **10** shown in FIGS. **3** and **4**, and detailed description of the lead frame configuration is therefore omitted herein.

While in the present embodiment the lead frame body **11** includes the die pads **25** and the lead portions **26** spaced from the die pads **25**, the lead frame body **11** is not limited to this configuration and needs only to include at least one die pad **25** and one lead portion **26**.

FIG. **17** shows a resin-attached lead frame **10A** according to a modification of the present embodiment. In the resin-attached lead frame **10A** of FIG. **17**, a reflecting metallic layer **51** is provided on an upper surface **23c** of the reflecting resin section **23**. The reflecting metallic layer **51** may be formed from a vapor-deposited aluminum layer or sputtered aluminum layer **12** or formed from other such kinds of metallic layers as of silver, rhodium, palladium, platinum, and/or copper. When a semiconductor device **20** is built into an illumination device, part of the light emitted from the LED element **21** will commonly or may reflect from the illumination device and return to an upper section of the semiconductor device **20**. Providing the reflecting metallic layer **51** as described above, however, prevents the light from being absorbed into the semiconductor device **20** after the light has returned to the upper section thereof.

FIG. **18** shows a resin-attached lead frame **10A** according to another modification of the present embodiment. The resin-attached lead frame **10A** shown, in FIG. **18** differs from that of the modification shown in FIG. **17**, in that a reflecting metallic layer **51** is not provided at a region **23d** on an upper surface **23c** of a reflecting resin section **23**, the region **23d** being a section that will be later cut by dicing as shown in FIG. **9(e)** and where the reflecting resin section **23** is exposed. The reflecting metallic layer **51** is provided at all other regions on the upper surface **23c** of the reflecting resin section **23**. The section **23d** at which the reflecting resin section **23** is exposed may exist nearly on a central section of the upper surface **23c** of the reflecting resin section **23** or on a position shifted in a horizontal direction from the central section of the upper surface **23c**. In this case, no foreign substances such as dicing swarf or metallic particles of the highly electroconductive aluminum or other materials will be included, which will in turn prevent short-circuiting due to any metallic foreign substances left after cutting.

FIG. **19** shows a resin-attached lead frame **10A** according to yet another modification. The resin-attached lead frame **10A** shown in FIG. **19**, unlike that of the modification shown in FIG. **17**, has a recess **52** concaved inward nearly in a central portion of an upper surface **23c** of a reflecting resin section **23**. A reflecting metallic layer **51** is provided in an

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entire internal region of the recess **52** (including a base **52a**) in FIG. **19**. Since a reflecting metallic layer **51** does not commonly exist in a section that has been cut by dicing, this section has a property of absorbing light. Additionally, when a semiconductor device **20** is built into an illumination device, part of the light emitted from the LED element **21** will commonly or may reflect from the illumination device and return to an upper section of the semiconductor device **20**. Since the region that absorbs the light (i.e., the section cut by dicing) is formed to have a small shape and size in FIG. **19**, this geometry prevents the light from being absorbed into the semiconductor device **20** after the light has returned to the upper section thereof.

FIG. **20** shows a resin-attached lead frame **10A** according to a further modification. The resin-attached lead frame **10A** shown in FIG. **20** differs from that of the modification shown in FIG. **19**, in that a reflecting metallic layer **51** is not provided at a base **52a** of a recess **52**, the base **52a** being a section that will be later cut by dicing as shown in FIG. **9(e)** and where a reflecting resin section **23** is exposed. The reflecting metallic layer **51** is provided at all other regions of the recess **52**. This configuration prevents light from being absorbed into a semiconductor device **20** after the light has returned to an upper section thereof. In addition, no foreign substances such as dicing swarf or metallic particles of the highly electroconductive aluminum or other materials will be included, which will in turn prevent short-circuiting due to any metallic foreign substances left after cutting.

Semiconductor Device Configuration

Next, a semiconductor device fabricated using the resin-attached lead frame shown in FIGS. **11** and **12** is described below per FIGS. **13** and **14**. FIG. **13** is a sectional view of the semiconductor device (SON type), and FIG. **14** is a plan view thereof.

As shown in FIGS. **13** and **14**, the semiconductor device **20A** includes a (singulated) lead frame **15** having a lead frame body **11** and a vapor-deposited aluminum layer or sputtered aluminum layer **12**, an LED element **21** disposed on a die pad **25** of the lead frame **15**, and a bonding wire (electric conductor) **22** that electrically interconnects the LED element **21** and a lead portion **26** of the lead frame **15**.

In addition, a reflecting resin section **23** is provided around the LED element **21**. Furthermore, the LED element **21** and the bonding wire **22** are both sealed with a light-transmissive sealing resin **24**.

Referring to FIGS. **13** and **14**, in addition to upper surfaces of LED element resting regions **14** on the lead frame body **11**, the vapor-deposited aluminum layer or sputtered aluminum layer **12** is further provided on inner walls **23b** of the reflecting resin section **23**. The vapor-deposited aluminum layer or sputtered aluminum layer **12** is shown in hatched form in FIG. **14**.

Besides, the semiconductor device **20A** shown in FIGS. **13** and **14** has substantially the same configuration as that of the semiconductor device **20** shown in FIGS. **5** and **6**, and detailed description of the semiconductor device configuration is omitted herein.

Method of Manufacturing the Resin-Attached Lead Frame

Next, a method of manufacturing the resin-attached lead frame **10A** shown in FIGS. **11** and **12** is described below using FIGS. **15(a)** to **(f)** and **16(a)** to **(d)**. The following description focuses mainly upon differences with respect to the steps shown in FIGS. **7(a)** to **(g)** and **8(a)** to **(c)**.

First as shown in FIG. **15(a)** to **(e)**, a lead frame body **11** having a die pad **25** and a lead portion **26** disposed away from the die pad **25** is fabricated in steps similar to those shown in FIG. **7(a)** to **(e)**.

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Next, a lower surface of the lead frame body **11** is provided with electrolytic plating to form a silver-plated layer **29** on each of a first outer lead portion **27** and a second outer lead portion **28**. Thus, as shown in FIG. **15(f)**, a lead frame **15** is obtained. At this time, the lead frame body **11** may alternatively have its entire surface plated with silver.

Next, a reflecting resin section **23** is formed on the surface of the lead frame body **11** to integrate the lead frame **15** and the reflecting resin section **23**, as shown in FIG. **16(a)** to **(c)**. The step of forming the reflecting resin section **23**, shown in FIG. **16(a)** to **(c)**, is substantially the same as the step of FIG. **8(a)** to **(c)**, except that the reflecting resin section **23** is formed before the vapor-deposited aluminum layer or sputtered aluminum layer **12** is formed.

Next as shown in FIG. **16(d)**, the LED element resting region **14** of the lead frame body **11** and the inner walls **23b** of the reflecting resin section **23** are provided with aluminum vapor deposition or aluminum sputtering to form a vapor-deposited aluminum layer or sputtered aluminum layer **12**. In this way, the resin-attached lead frame **10A** shown in FIGS. **11** and **12** is obtained.

A method in which the semiconductor device **20A** shown in FIGS. **13** and **14** is fabricated using the thus-obtained resin-attached lead frame **10A** is substantially the same as the method shown in FIG. **9(a)** to **(f)**, and detailed description of the fabrication method is omitted herein.

As set forth above, the present embodiment enhances the extraction efficiency of the light from the LED element **21** and prevents the lead frame **15** from degrading with time.

In accordance with the present embodiment, the vapor-deposited aluminum layer or sputtered aluminum layer **12** is also provided on the inner walls **23b** of the reflecting resin section **23**. The aluminum constituting the vapor-deposited aluminum layer or sputtered aluminum layer **12** does not degrade even when exposed to the ultraviolet radiation emitted from the LED element **21**, such that the reflecting resin section **23** can be prevented from degrading even when exposed to the ultraviolet radiation.

The invention claimed is:

1. A resin-attached lead frame, comprising:

a lead frame main body including:

a plurality of die pads;

a plurality of lead portions each spaced from a corresponding one of the plurality of die pads; and

LED element resting regions each formed over an area including an upper surface of one of the plurality of die pads and an upper surface of one of the plurality of lead portions; and

a reflecting resin section surrounding each of the LED element resting regions of the lead frame main body; wherein:

a vapor-deposited aluminum layer or a sputtered aluminum layer to reflect a light from an LED element is provided on upper surfaces of the LED element resting regions of the lead frame main body;

each of the plurality of die pads and each of the plurality of lead portions are coupled to an adjacent die pad and/or an adjacent lead portion via a tie bar;

the vapor-deposited aluminum layer or sputtered aluminum layer is further provided on an upper surface of the tie bar;

the tie bar has a length direction, a width direction, and a thickness direction, the thickness direction being in a direction from the upper surface of the tie bar to a lower surface of the tie bar that is opposite to the upper surface, and the length and width directions being

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perpendicular to each other and defining a plane that is orthogonal to the thickness direction; and
the tie bar is interposed in the thickness direction between portions of the reflecting resin section.

2. The resin-attached lead frame according to claim **1**, wherein the vapor-deposited aluminum layer or the sputtered aluminum layer is further provided on an inner wall of the reflecting resin section.

3. The resin-attached lead frame according to claim **1**, wherein the plurality of LED element resting regions of the lead frame main body are arranged lengthwise and breadthwise.

4. The resin-attached lead frame according to claim **1**, wherein:

the lead frame main body is formed from any one of copper, a copper alloy, and a 42-alloy, and

at least the upper surfaces of the LED element resting regions are worked into a mirror-like finish having a roughness level of 0.01 μm to 0.10 μm in arithmetic average height "Sa," and 2 μm to 18 μm in roughness curvilinear element average length "Sm".

5. The resin-attached lead frame according to claim **1**, wherein a silver-plated layer is provided on a lower surface of each of the plurality of lead portions as well as on a lower surface of each of the plurality of die pads of the lead frame main body.

6. The resin-attached lead frame according to claim **1**, wherein grooves for enhancing adhesion between the lead frame main body and the reflecting resin section are formed on an upper surface of the lead frame main body.

7. The resin-attached lead frame according to claim **1**, wherein a reflecting metallic layer is provided on an upper surface of the reflecting resin section.

8. The resin-attached lead frame according to claim **7**, wherein:

the upper surface of the reflecting resin section has a part that is cut by dicing, and

the reflecting resin section is exposed at the part.

9. The resin-attached lead frame according to claim **7**, wherein an inward concaved recess is formed on the upper surface of the reflecting resin section.

10. The resin-attached lead frame according to claim **1**, wherein an entirety of the upper surface of the tie bar and an entirety of the lower surface of the tie bar are covered by the reflecting resin section.

11. A resin-attached lead frame, comprising:

a lead frame main body including:

a die pad;

a lead portion disposed apart from the die pad; and

an LED element resting region formed over an area including an upper surface of the die pad and an upper surface of the lead portion; and

a reflecting resin section surrounding the LED element resting region of the lead frame main body;

wherein:

a vapor-deposited aluminum layer or a sputtered aluminum layer to reflect a light from an LED element is provided on an upper surface of the LED element resting region of the lead frame main body;

the die pad and the lead portion are each coupled to an outer frame via a tie bar;

the vapor-deposited aluminum layer or sputtered aluminum layer is further provided on an upper surface of the tie bar;

the tie bar has a length direction, a width direction, and a thickness direction, the thickness direction being in a direction from the upper surface of the tie bar to a lower

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surface of the tie bar that is opposite to the upper surface, and the length and width directions being perpendicular to each other and defining a plane that is orthogonal to the thickness direction; and

the tie bar is interposed in the thickness direction between portions of the reflecting resin section.

12. The resin-attached lead frame according to claim 11, wherein an entirety of the upper surface of the tie bar and an entirety of the lower surface of the tie bar are covered by the reflecting resin section.

13. A lead frame comprising:

a lead frame main body including:

a plurality of die pads;

a plurality of lead portions each spaced from a corresponding one of the plurality of die pads; and

LED element resting regions each formed over an area including an upper surface of one of the plurality of die pads and an upper surface of one of the plurality of lead portions;

wherein:

a vapor-deposited aluminum layer or a sputtered aluminum layer to reflect a light from an LED element is provided on upper surfaces of the LED element resting regions of the lead frame main body;

each of the plurality of die pads and each of the plurality of lead portions are coupled to an adjacent die pad and/or an adjacent lead portion via a tie bar, and

the vapor-deposited aluminum layer or sputtered aluminum layer is further provided on the tie bar.

14. A lead frame comprising:

a lead frame main body including:

a die pad;

a lead portion disposed apart from the die pad; and an LED element resting region formed over an area including an upper surface of the die pad and an upper surface of the lead portion;

wherein:

a vapor-deposited aluminum layer or a sputtered aluminum layer to reflect a light from an LED element is provided on an upper surface of the LED element resting region of the lead frame main body;

the die pad and the lead portion are coupled to an outer frame via a tie bar; and

the vapor-deposited aluminum layer or sputtered aluminum layer is further provided on the tie bar.

15. A method for manufacturing a resin-attached lead frame, the method comprising:

providing a lead frame main body including:

a plurality of die pads;

a plurality of lead portions each spaced from a corresponding one of the plurality of die pads; and

LED element resting regions each formed over an area including an upper surface of one of the plurality of die pads and an upper surface of one of the plurality of lead portions;

providing a vapor-deposited aluminum layer or a sputtered aluminum layer to reflect a light from an LED element on upper surfaces of the LED element resting regions of the lead frame main body; and

providing a reflecting resin section surrounding each of the LED element resting regions of the lead frame main body;

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wherein:

each of the plurality of die pads and each of the plurality of lead portions are coupled to an adjacent die pad and/or an adjacent lead portion via a tie bar;

the vapor-deposited aluminum layer or sputtered aluminum layer is further provided on an upper surface of the tie bar;

the tie bar has a length direction, a width direction, and a thickness direction, the thickness direction being in a direction from the upper surface of the tie bar to a lower surface of the tie bar that is opposite to the upper surface, and the length and width directions being perpendicular to each other and defining a plane that is orthogonal to the thickness direction; and

the tie bar is interposed in the thickness direction between portions of the reflecting resin section.

16. The method according to claim 15, wherein an entirety of the upper surface of the tie bar and an entirety of the lower surface of the tie bar are covered by the reflecting resin section.

17. A method for manufacturing a resin-attached lead frame, the method comprising:

providing a lead frame main body including:

a plurality of die pads;

a plurality of lead portions each spaced from a corresponding one of the plurality of die pads; and

LED element resting regions each formed over an area including an upper surface of one of the plurality of die pads and an upper surface of one of the plurality of lead portions;

providing a reflecting resin section surrounding each of the LED element resting regions of the lead frame main body; and

providing a vapor-deposited aluminum layer or a sputtered aluminum layer to reflect a light from an LED element on an inner wall of the reflecting resin section as well as on upper surfaces of the LED element resting regions of the lead frame main body;

wherein:

at least one of the plurality of die pads and at least one of the plurality of lead portions are coupled to an outer frame via a tie bar;

the vapor-deposited aluminum layer or sputtered aluminum layer is further provided on an upper surface of the tie bar;

the tie bar has a length direction, a width direction, and a thickness direction, the thickness direction being in a direction from the upper surface of the tie bar to a lower surface of the tie bar that is opposite to the upper surface, and the length and width directions being perpendicular to each other and defining a plane that is orthogonal to the thickness direction; and

the tie bar is interposed in the thickness direction between portions of the reflecting resin section.

18. The method according to claim 17, wherein an entirety of the upper surface of the tie bar and an entirety of the lower surface of the tie bar are covered by the reflecting resin section.

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